Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

ACORN Design Concepts

December 15, 2021

Project ACORN

- Vision statement:
  - *The Accelerator Controls Operations Research Network (ACORN) project will modernize the accelerator control system and replace end-of-life accelerator power supplies to enable future operations of the Fermilab Accelerator Complex with megawatt particle beams. The control system will be a unified system that satisfies user requirements, is integrated with and supports operating experiments, is maintainable and adaptable to future needs, and empowers users to achieve their research goals.*

Design Alternatives

As a DOE O413.3B project, ACORN is required to evaluate alternatives for the design of the accelerator control system:

Four alternatives have been specified by DOE:

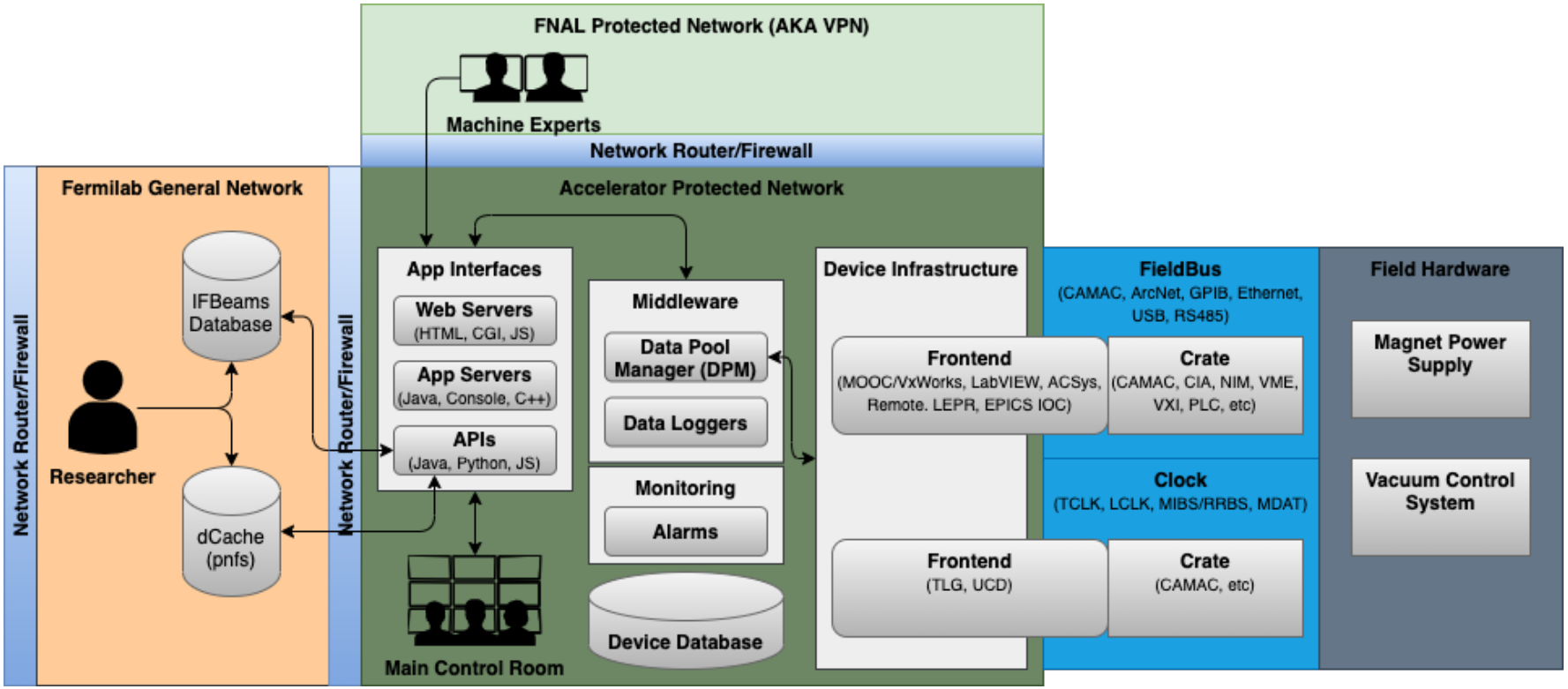
- Alternative I: Status Quo
- Alternative II: One-For-One Replacement
- Alternative III: Centralized Architecture
- Alternative IV: Decentralized Architecture

Alternative I – Status Quo

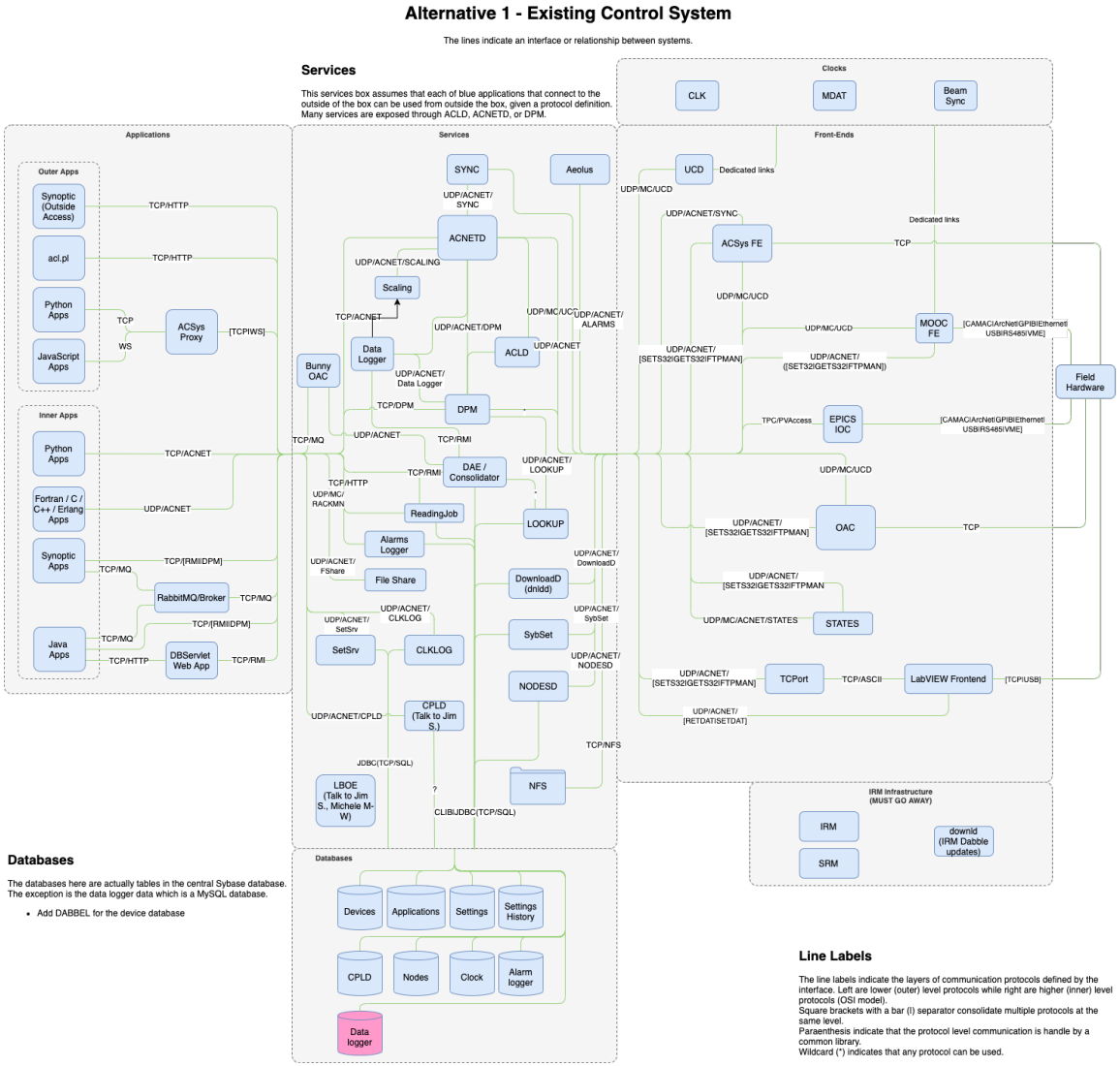
- Null alternative: do nothing
  - This is the alternative if ACORN does not modernize the accelerator control system
  - Used as a baseline for comparison

- Operational risks
  - Aging technology and obsolescence
  - Lack of expertise due to people leaving the lab
  - Hidden operational costs and risks in the long run

Alternative 1 high-level block diagram



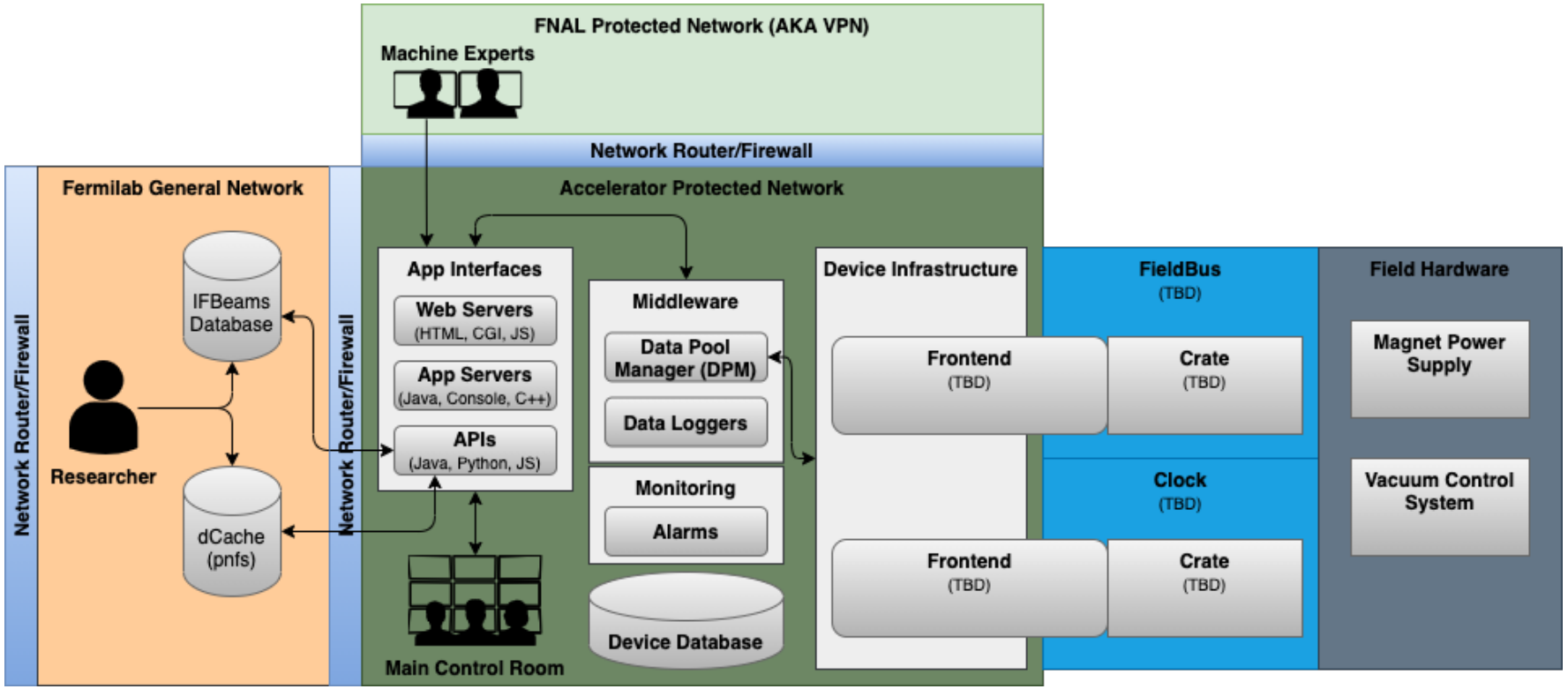
Alternative 1 interface diagram



Alternative II – One-For-One Replacement

- Operations risks are addressed in the context of the current control system architecture
  - Hardware is replaced with newer versions, as equivalent as possible
  - Software gets refactored to use newer technologies / frameworks / programming languages, keeping their functionality and interfaces
  - Interfaces are kept wherever is feasible
    - Protocols between components
    - Links / communication channels
    - User applications
    - Central infrastructure
  - Still need same expertise as Alternative #1
- Hidden operational costs and risks in the long run

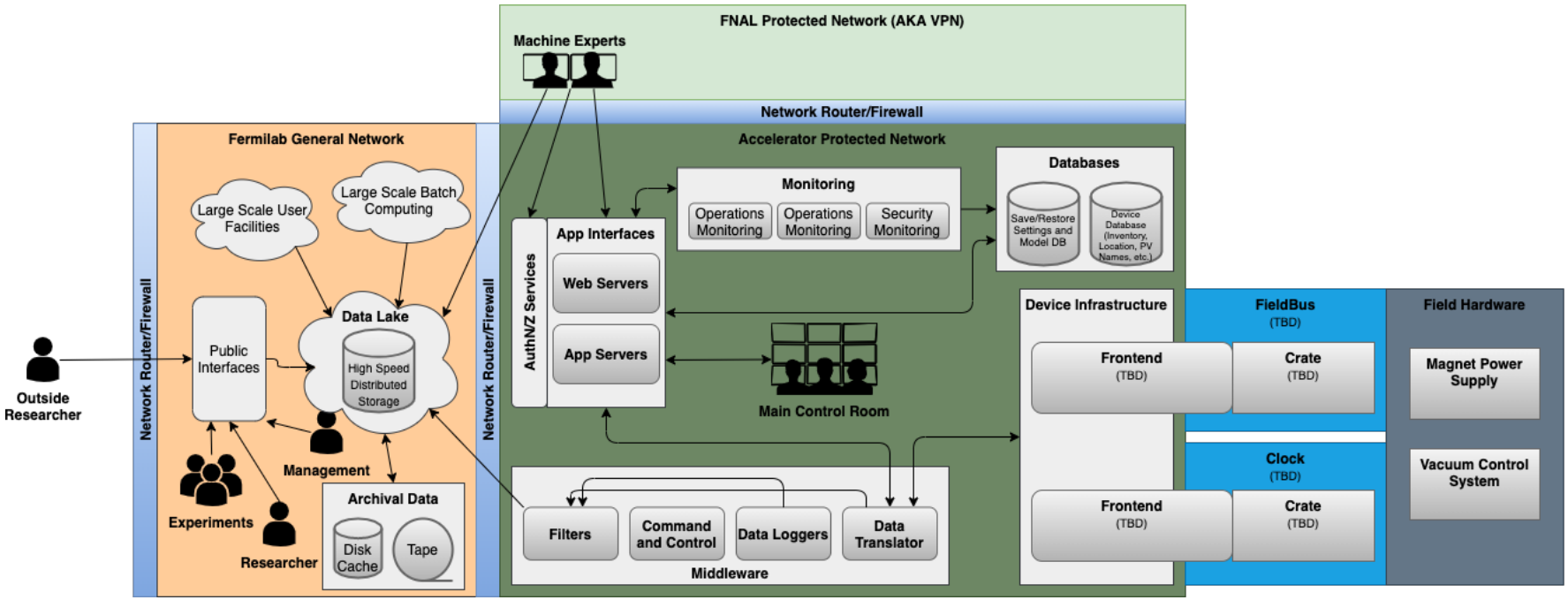
Alternative 2 high-level block diagram



Alternative III – Centralized Architecture

- Rearchitect the control system based on a centralized architecture
  - Centralized command and control logic
  - Centralized data logger service / data translation
  - Centralized monitoring
  - Uniform interface for control and data acquisition
    - Everything "funnels" through centralized infrastructure (simple networking)
    - Complexity is handled by the centralized infrastructure (can add new services with less impact)
    - Consistent feature set across systems (vertical scaling)
- Remove aging technology
- Minimize the amount of specialized expertise needed to maintain and operate the accelerator and control system
- Eliminate hidden operational costs and risks in the long-term

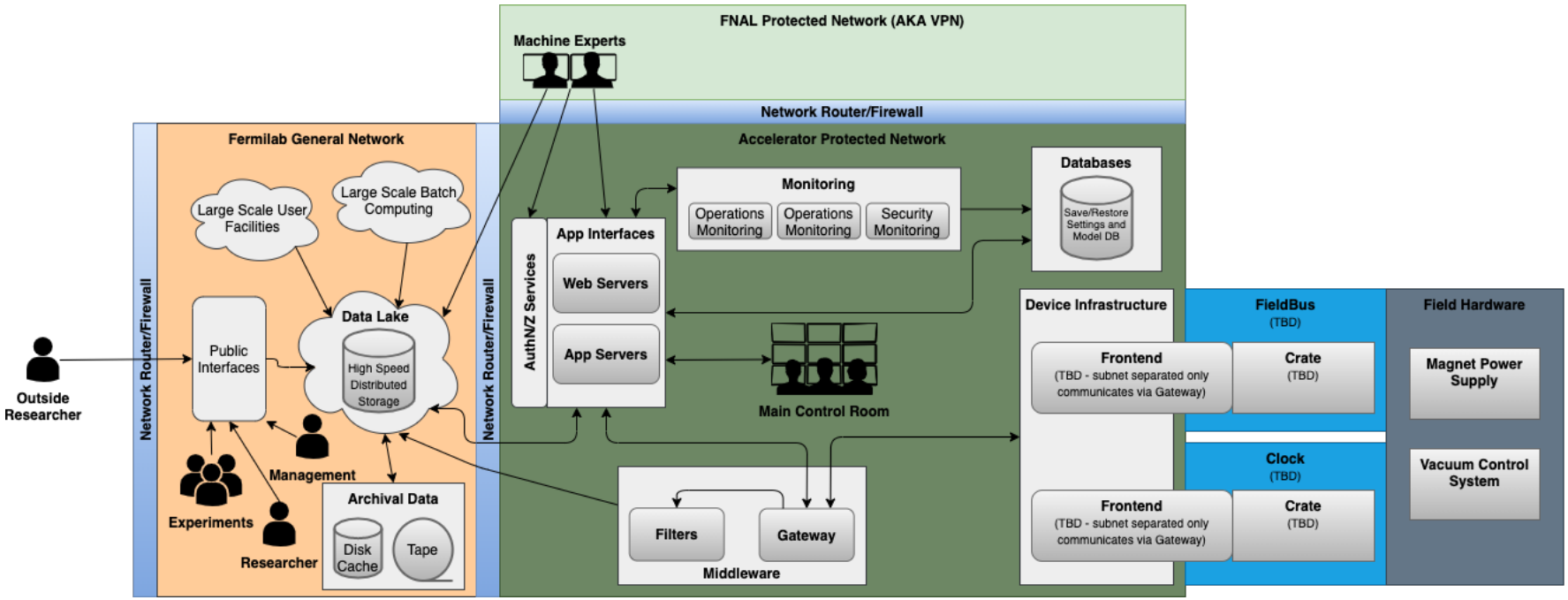
Alternative 3 high-level block diagram



Alternative IV – Decentralized Architecture

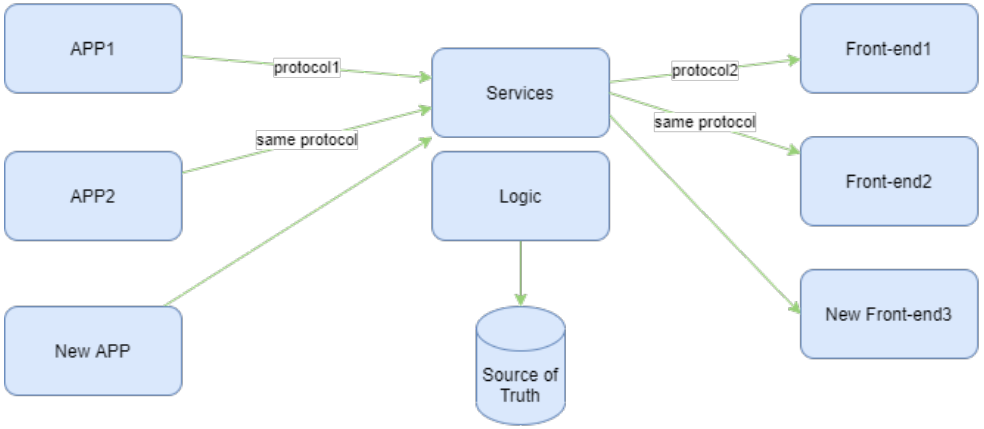
- Rearchitect the control system based on a decentralized architecture
  - Command and control logic is distributed among front-ends
    - Data logger and data translation
    - Complex networking
    - Adding front-ends is a simpler process (horizontal scaling)
  - Client applications contain inherent knowledge of the physical implementation of the control system
    - Know what data is available and how to query for the data
- Remove aging technology
- Minimize the amount of specialized expertise needed to maintain and operate the accelerator and control system
- Eliminate hidden operational costs and risks in the long-term

Alternative 4 high-level block diagram

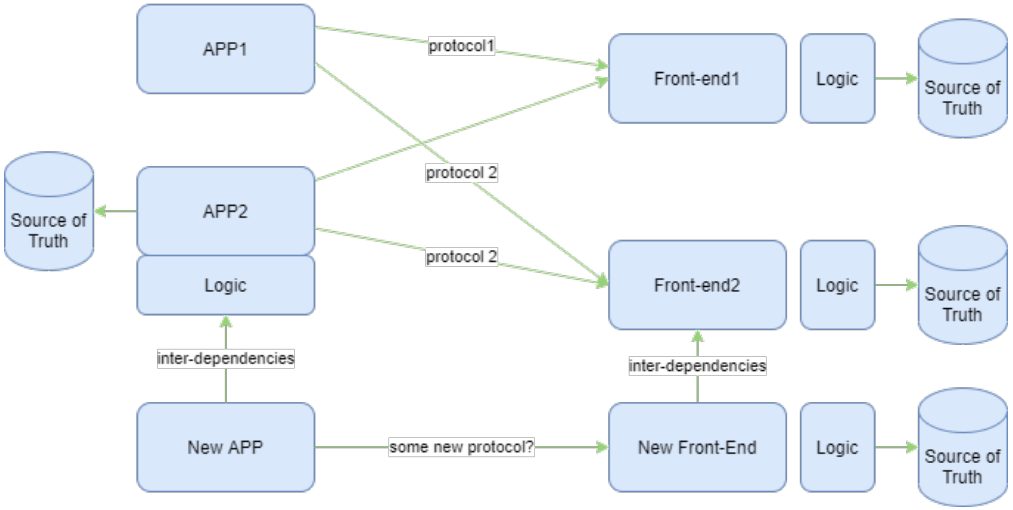


Centralized vs Decentralized Architecture

Centralized Architecture



Decentralized Architecture



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